

TEMPERATURES AND MINIMUM THICKNESS OF THE INACTIVE SURFACE LAYER OF COMET HALLEY

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The effects of a nonvolatile mantle on the thermal state of a comet nucleus are investigated. Our original computer model (Fanale and Salvail, 1984) was modified so that temperatures can be computed through a thin dust mantle to the center of a 5 km spherical nucleus in the orbit of P/Halley. No attempt is made to simulate the formation of a mantle. Results are obtained for various specified values of initial mantle thickness and thermal conductivity to determine their effects on temperature profiles through the mantle. The minimum thickness of mantle that can withstand ejection by sublimating gasses is also calculated as a function of mantle thermal conductivity. This is assumed to occur when the vapor pressure at the ice interface exceeds the lithostatic pressure of the mantle. Calculations were performed for ten or more orbits until temperatures in the mantle reached a near steady state. Results indicate that mantles as thin as 4 cm and 14 cm, for thermal conductivities of 600 and 6000 ergs/cm-s-K, respectively, will remain intact. Surface temperatures as high as 511K at perihelion and 400K at the position of spacecraft encounter were computed at 0° latitude for an upright, rotating nucleus. Ice interface temperatures were raised by different amounts during each orbit, depending on mantle thickness and thermal conductivity, until steady state was reached. After temperatures in the mantle reached a steady state, ice surface temperatures were constant throughout the orbit due to the large difference in the thermal conductivities of the mantle and the more compact icy nucleus. These results imply that relatively small nonvolatile masses emplaced randomly in comet nuclei could produce an irregular, permanently mantled surface and could also account for the apparently random location of active areas.

Reference

Fanale, F.P. and J.R. Salvail (1984). An idealized short period comet model: Surface insolation, H₂O flux, dust flux and mantle evolution. Icarus 60, 476-511.